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Designing of network planning system for small-scale manufacturing

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Abstract. The paper presents features of network planning in small-scale discrete production. The procedure of explosion of the production order, considering multilevel representation, is developed. The software architecture is offered. Approbation of the network planning system is carried out. This system allows carrying out dynamic updating of the production plan.

1. Introduction

Network methods are widely used in the processes of production planning. The use of such algorithms makes it possible to visualize complex control processes, improve their efficiency, and carry out a multifaceted study of the control system of the production process and the organization as a whole. The main result of network planning is a planned schedule, in which the complex production tasks are divided into separate, arranged in the technological and time sequence, works. At the same time, a significant number of parameters are subjected to optimization that promotes an increase of activity coordination of various divisions of the enterprise [1–3].

Models of network planning acquire special significance at discrete assembly plants differing in a small batch. In such plants, it is difficult to apply linear models of planning due to significant difficulties in their dynamic adjustment in the event of a change in the initial planning conditions. Despite the presence of a large number of solutions for automation of planning processes, most of them are oriented to large-scale machine-building production. Known methods, algorithms and information systems of planning cannot be directly applied to the organization of the operational production planning system at the enterprises that have the specifics of release of hi-tech assembly production of a small batch [4, 5].

2. Features of planning under small-scale manufacturing

Network planning is most demanded in case of frequent change of the nomenclature of components, release of a small batch of products, frequently replacing each other, emergence of unscheduled production orders. For such production case, planned schedules are constructed using the principles of network planning for the reason that linear structures do not allow one to distribute rationally production and financial resources in time. At the same time, the used method of network planning has to provide the most complete initial and current information in the planning of work to monitor the progress of their implementation and the operative updating stages of the plan [6–9].

For realization of management of the dynamic system for planning, it is possible to use information and dynamic models for the logical-mathematical description process of planning and automation of calculations of necessary parameters. The network model allows considering all complexes of works. The model includes both static scheduling and dynamic management of works throughout the

production cycle. Works included in the network model are associated with items from the production order by means of an explosion. The quality of the network schedule will depend on reliability of the duration parameters and also correct implementation of the procedure of explosion.

The algorithm of explosion of the order (division of the whole into parts) represents performance of the following operations [6]:

1. Define the head blocks of the production order.
2. Check the head and nested blocks for the presence of subblocks (do that until all blocks are opened).

The result of the explosion is a tree structure – bill of materials (BOM). This is represented in the database of the planning system in the form of a table. For determined estimate of operational duration of a batch, positions for a single operation (a sequential method of transferring a processed batch of parts) can be installed on included work with labor input standards:

$$Dur_{op} = \sum_{i}^{q_O} (T_{nv} \times n + T_{m-o} \times q_o)$$

where the following is specified: T_{nv} – calculation time for each operation; n –batch size (quantity of all positions to order); T_{m-o} – time between operations ; q_o – number of operations.

For calculation of manufacturing duration of batch positions for shops, it is necessary to sum the estimates of the operational durations taking into account the time between the shops, which is equated to unity.

In the process of developing manufacturing software, a volume planned schedule and planned daily tasks, information is used about the current production process. Such information reflecting results of work of shops is periodically processed and finally formed by each new planning period in the form of the corresponding total. The timeliness of receipt of information, its completeness and reliability, directly influence quality of the developed programs and production orders. Therefore, these factors are taken as the main criteria for creating a system of manufacturing planning.

3. Design of a network planning system

Manufacturing planning at Russian enterprises is often conducted manually or using automated linear models. Shortcomings of linear models are shown by small-scale production. Automation of network planning can be realized by a three-level scheme. Planning and management of manufacturing processes in such architecture is carried out through an automated workstation at the level of shops and departments. Operators of the automated workstation use web-applications that implement business logic. Such applications can be developed in the C# for the ASP.NET Web Forms architecture and ASP.NET MVC and hosted on the Application Server (IIS). At the same time, part of the logic and calculations that is related to visualization is implemented in the JavaScript language using the JQuery library (Fig 1).

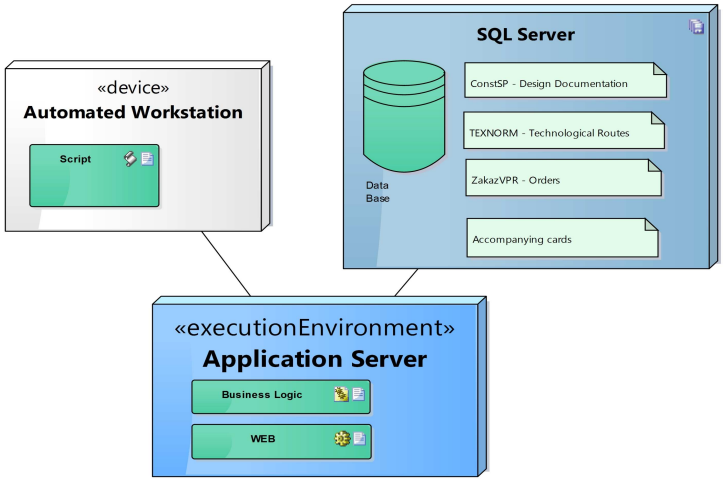

Figure 1. The architecture of the network manufacturing planning system

For the main workspace and the settings page visualization and processing of the logic of user interaction with the elements of the graphical interface of the planning system is implemented in HTML. The procedure for exploding an order begins with the head blocks, and then they are expanded into separate positions. The algorithm for implementing the procedure is shown in Fig. 2. The sequence opening of aggregated works is shown in Fig. 3.

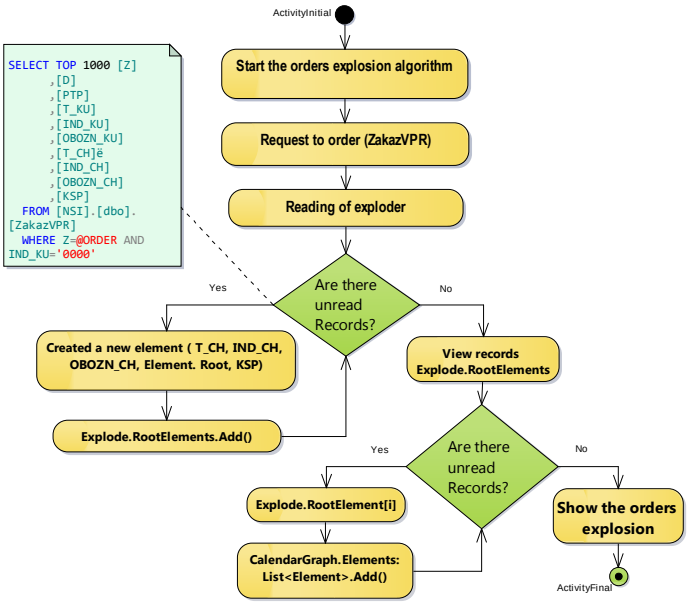

Figure 2. Implementation of an algorithm of explosion of the production order

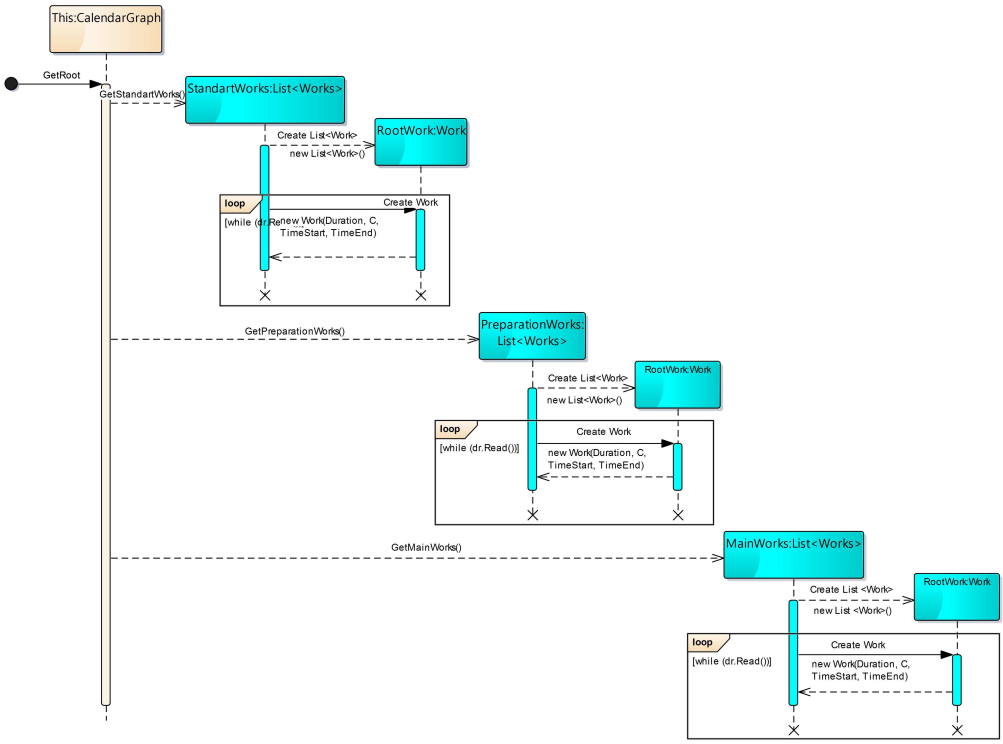

Figure 3. The sequence of opening aggregated works on the network model

Similar to the one shown in Fig. 3, the sequence is developed for each of the main stages of the algorithm of explosion of the production order. Such complex of developed sequences made it possible to proceed refining the software architecture of the network planning system and obtaining a

prototype. The logical structure of the prototype is shown in Fig. 4. The prototype interface of the automated network planning system is designed taking into account architectural and functional requirements (Fig. 5).

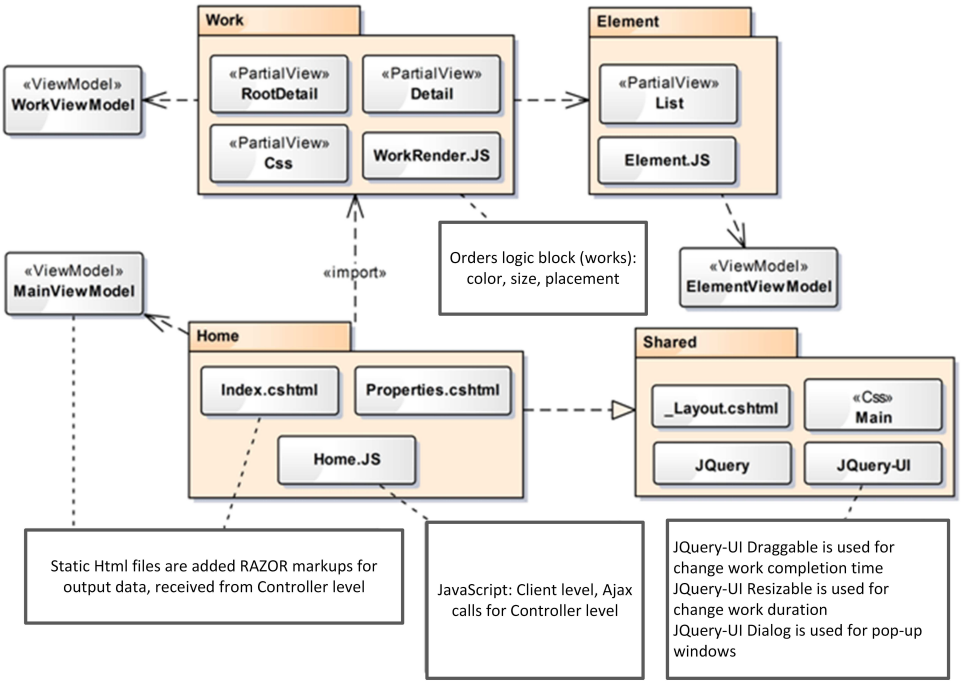

Figure 4. The logical structure of the network planning system

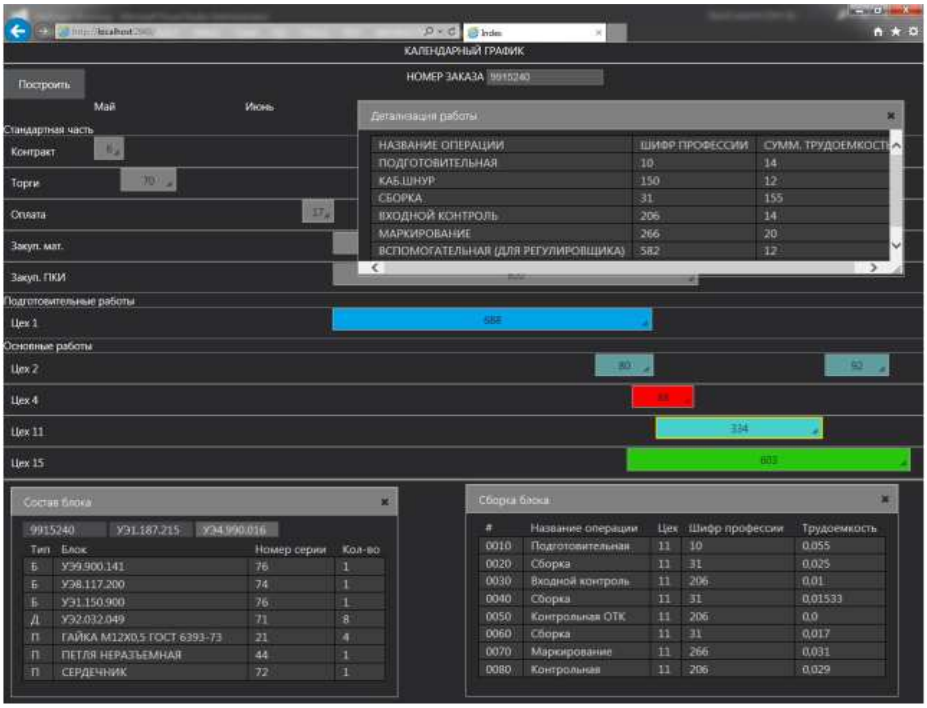

Figure 5. Graphic interface of a system prototype of network manufacturing planning (in Russian)

The purpose of development of an algorithm is creation and a possibility of dynamic updating of the schedule production diagram differing in frequent transfers of works, terms of their beginning and the termination, emergence of new works (orders) in a manufacturing cycle. Developed by the proposed

algorithm and architecture, the system allows for automated manufacturing planning by order number. Another array of the required information comes from adjacent information systems of the enterprise.

4. Conclusion

The paper proposes the architecture of an automated network planning system for small-scale discrete manufacturing characterized by a wide range of purchased products and components, parts and assembly units with simultaneous frequent changes in the equipment produced. Implemented in it, the algorithm of exploding production orders allows one to organize an effective process of production planning in conditions of frequent adjustments to the work performed and their parameters. The algorithm is unified for the specified type of production, adapted to different types of orders. The offered architecture is tested during creation and introduction of the prototype of the application of the automated system of planning the radio-electronic small-scale assembly production. In the future, the developed algorithm and architecture can be used in the design of automated network planning systems for small-scale discrete manufacturing such as project type.

Acknowledgments

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